Challenges of Digital Collaboration in The South African Construction Industry

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Abstract

Digital collaboration which involves the interaction between the construction world and the digital world in recent times, has gained increasing interest within the South African Architecture, Engineering, and Construction industry. This is because the construction business is at the edge of a digital revolution and countless technologies are promising inventive answers to age-old issues of conveying project on-time, within budget, and to customers' determinations. Despite these enticing benefits of digitalization, the problem of full implementation is still evident within the industry. This study reports the challenges of digital collaboration and the possible strategies for enhancing the use of digital tools in the country. The study adopted a survey design and data were gathered through the use of questionnaire administered on construction professionals in Gauteng province. Data gathered were analyzed using appropriate descriptive statistics. Result reveals that the major challenges of digital collaboration are lack of training, expensiveness of digital technologies, poor adoptability of standards, and challenge of interoperability. To remedy these problems, there is need for; the creation of avenues for proper education and training on digital collaboration, management encouraging digital collaboration usage in workplaces, and ensuring easy access to loans from financial institutions for companies to implement digital collaboration.

Keywords

Digital Collaboration, Digital Technologies, Digital Tools, ICT, South African AEC Industry

1. Introduction

All around the world, new technologies are being developed and this is transforming and revolutionizing all, from the basic to the intricate functions of life, and the Architecture, Engineering and Construction (AEC) industry is no exception. According to Halim (2010) there is no profession that can effectively succeed in solving its 21st century development challenges unless the professional visions, aspiration, mission and strategies are fundamentally anchored in the realm of knowledge creation and strategically driven by technology. Using the guide of digital and collaboration technology the construction businesses around the world has turned out to be less intricate, projects being done on time, profitability expanding, better nature of work and more customers' satisfaction is being attained (Van Leeuwen, 2003).

Digital technology which helps in the generation, stockpiling, data treatment, encouragement of distinctive types of correspondence amongst people and automatic frameworks, and also between electronic frameworks, is today a popular concept among construction professionals around the world (Ibem and Laryea, 2014). This popularity can be attributed to the recent attention given to the concept of building information modelling (BIM). BIM utilizes cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and it is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility (Ashcraft,

2007). According to Van Leeuwen (2003) construction tasks that need BIM are majorly tasks in which an expensive number of professionals need to cooperate on the outline and generation of a perplexing item that is exceptional. A large portion of these participants in most cases do not cooperate to achieve the desired outcome. Thus, the introduction of BIM has eliminated such shortcomings and made the attainment of those unsurmountable task possible. McGraw-Hill (2012) observed that major construction projects increasingly depend on BIM to be finished carefully, and a lot of businesses in the AEC industry make sure they utilize BIM as a catalyst for IT-based change in their operations.

Digital technology has grown drastically in the past few years (Sun *et al.*, 2015) and its adoption in the delivery of construction products is seen as digital collaboration. Recently, there has been some growing interest in digital collaboration in the South African AEC industry. This can be as a result of the fact that digital collaboration serves as a catalyst for innovation and also promises to deliver integration across people, groups, and organizations working in the construction supply chain (Merschbrok, 2014; Shen *et al*., 2010). However, there are factors that need to be studied in order to improve the digital status in the South African AEC industry, for it to be updated with the global digital knowledge in the AEC industries around the world.

There are different published studies that have been done on digitalization in construction (El-Mashaleh, 2007; Gaith *et al.*, 2012; Ibem and Laryea, 2014; Ibironke *et al.*, 2011; Oladapo, 2007; Peansup and Walker, 2005). Several benefits of the adoption of Digital technologies have been revealed. The study of Peansupap and Walker (2005) however shows that numerous AEC firms have found that the digital technology venture has failed to live up to their expectations. One outstanding issue is the absence of understanding the most effective digital technology to rely upon in the industry. This issue can also be interpreted as the problem of the most effective digital tool that will serve the different professions within the industry and to a large extent eliminate issues of communication gap among these professions. This is because a major construction process demands heavy exchange of data and information between project participants on a daily basis (Masqod *et al*., 2004). It is based on this background that this study examined the challenges of digital collaboration in the South African construction industry, and also assessed the possible strategies for enhancing the use of digital tools within the industry, with a view to providing the opportunity for increasing the use of these technologies and achieving more effective construction process.

2. Review of Related Literatures

2.1 Overview of Digital Collaboration

Collaboration is a joint effort of people or organisation with the aim of achieving a certain goal. The collaboration between the construction industry and digital technology is geared towards making the construction industry more efficient. In the last two decades the development organizations have received useful Digital technologies in an effort of backing the expanding requests for business proficiency, efficiency, quality and culmination (Arayici 2015). Digital collaboration is commonly used in big construction projects and has also been used as a connection between the industry and technology (McGraw-Hill 2012).

Having built up an operational meaning of digital collaboration in the construction process and its element exercises in the on-going divisions; it is additionally essential that this study portray what we allude to as digital technologies. In undertaking this, the study looked into the development of digital technologies, recognizing its extraordinary qualities plus the diverse features at present that are accessible in the construction industry. According to Hamelink (1997) there are four stages in the development of digital technologies. The primary stage was the pre-1838 period at the point when the main telegraphic transmission was designed by Samuel Morse, and data transmission was done physically. The second stage was the creation of electricity and electro-mechanical force, which prompted the advancement of correspondence contraptions like telegraph, telephone, radio and TV. The third stage was the combination of telecommunication and computer advances in the 1950s, which were singly utilized, and data was taken care of as a part of simple mode. The last stage highlighted the substitution of the simple method of data transmission with the digital framework. This started in the 1960s with the advancement of computerized switches and transmission offices and quickly developed in the 1980s when advanced items like smaller plates (CDs) were brought into the business sector.

It is clear that the hatching time of information, communication and technology (ICT) was more than 100 years, while their digitization, that is the procedure through which sound, content, voice or picture is changed over into computerized and dual computer code, (Saad and Hancher, 1988) took an additional 20 years or so to fulfil.

Underwood and Isikdag (2011) define the digitization of ICTs as digital innovation that has offered growth to frameworks and applications. Examples are the web, portable/smart/android gadgets, long range informal communication, virtualization, distributed computing advancements, sensor systems and few others. Froese (2010) also recognised three stages in the uptake of digital technologies in the construction process exercises, and stated that the primary period of uptake of digital technologies in construction was the utilization of stand-alone apparatuses, for example, the use of CAD framework to bolster assignments like building design, structural investigation and expense assessing.

Survey shows that digital collaboration has grown drastically globally (Jung and Lee, 2015; Sharif 2011; Succar 2009). Jung and Lee (2015) gave the percentages that demonstrates the usage of digital technologies with particular respect to BIM in the Middle East/Africa and the world as seen in Table 1. However, despite this impressive percentage in some of the key construction areas, the Middle East/Africa is still considered as being in the "beginner phase" in terms of the adoption of BIM in the world. This therefore begs the question of what factors are actually contributing to the implementation of digital collaboration in Africa, most especially the South African construction industry.

Table 1. Usage of Digital technologies in the Middle East/Africa and the world

Digital Collaboration	Middle East/Africa	Globally
1. 3D Coordination	91%	85%
2. Cost Estimation	58,3%	75%
3. Existing condition modelling	66.7%	74.3%
4. Design Authoring	83.3%	63.4%
5. Structural analysis	50%	60%
6. Maintenance schedule	16.7%	30%
7. Building system analysis	25.0%	33.4%

Source: Jung and Lee (2015)

2.2 Challenges of Digital Collaboration

A major challenge of digital collaboration is observed to be that interoperability which refers to the capacity of associations/professions within the AEC industry, to trade, offer or incorporate data and business forms, crosswise over data frameworks or authoritative practice, the absence of which amounts to the failure of diverse frameworks to connect adequately (Aranda-Mena *et al*., 2006; Eastman *et al*., 2011). This practice can be overwhelming as a result of the degree of fracture, differing qualities in data prerequisites, inflexibility of data schemas (standards), requesting innovation competency necessities, and more extensive business goals, which anticipate merchants' compatibility in the improvement of programming and frameworks that interoperates (Doller and Hegedorn 2008; Isikidag *et al*., 2007). Another issue is that of training. Most institutes do not provide specific module for digital training and this has a negative effect on the AEC industries, as companies have to further train their graduates. This can serve as a source of discouragement to the implementation of digital technologies. Sacks and Barak (2010) opined that absence of well-trained technological staff is a noteworthy requirement preventing the utilization and appropriation of technological innovations in construction.

Data security and protection is also important for effective digital collaboration (Redmond *et al.*, 2012). Guarantee that information and data are only open to the right individuals and programming applications is important. Computer security and protection procedures identified with cooperative trade, borders on the security of important parts of information, resources, data and assets that incorporates scholarly properties in these pervasive and frequently open information era (Zeng *et al.*, 2012). Access to information in cooperative information technology situations ought to be open and accessible only to the right individuals at the right times. Aside security and privacy issue, the advancement of requirement for information trade in task conveyance has developed in the course of the most recent two decades (Eastman *et al*., 2008). Standards keep on lacking, and the ability of handling incremental level of subtle element requiring consistent modification. Generally, divided condition of improvement over the different orders has brought about changing levels of development in the condition of models in the AEC, geospatial, vitality or maintainability fields (Lapierie and Cotep, 2008). This issue of maintaining standard can to a large extent hamper the full implementation of digital collaboration if not given the needed attention.

In order studies, El-Mashaleh (2007) discovered that in the construction industry in Jordan, the main obstacles to digitalization is the financial cost of using it, the cost of maintenance as well as ineffective staff training. Oladapo

(2007) also noted that factors like insufficient/erratic power supply, job sizes, high cost of technologies, fear of virus attack, high cost of engaging computer staff, lack of management desire and appreciation of digital technologies, security, low return on investment, personnel abuse, and fear of technology making professionals redundant, are some of the challenges facing the implementation of digital collaboration particularly among Quantity Surveyors in Nigeria. A similar observation as regards the management influence on the implement of digital technologies was made by Oyediran and Odusami (2005). In addition, Rezgui *et al.* (2004) and Brewer *et al*. (2005) asserted that the reasons for the relatively low adoption of digital technologies in construction are; issues relating to the legal ramifications of electronic communications, vague security framework, and issue of trust. Also, organizational and human issues were highlighted as the key factors affecting the use of technologies in the construction sector by Oyediran and Akintola (2011).

2.3 Strategies to Enhance the Utilization of Digital Technology

Past literatures have shown that staff training on digital technologies is crucial to the utilization of same within the construction industry. These training programs can be designed to teach users the hands-on skills required for the effective usage of digital tools within their particular discipline. The training can be organized by software vendors at their training facilities and management of construction companies can take advantage of these trainings to groom their staffs in the use of needed digital tools (Becerik 2004). Becerik (2004) further stated that industry associations ought to back appropriation of the advances in digital collaboration with an attention on the most proficient method to utilize and apply them beneficially in the industry. In similar manner, scholastic foundations ought to understand the duty to educate their understudies in the new advances, and creative approaches towards utilizing them.

Mutesi (2009) submitted that the top three possible solutions to the use of digital technologies are; loans from Government for technological development, improving and employing professionals with technological skills, and sufficient staff training. Kundishora (2006) earlier noted measures such as loans from government, adequate power supply, lowering cost of digital tools such as computers, ensuring that every department develops and manages a computerized information system, promote awareness in the use of technology, and promote local research and development, as being crucial to strengthening digital technology and encouraging collaboration.

3. Research Methodology

This study investigated the challenges of digital collaboration and the possible strategies for enhancing the use of digital technologies in the South African construction industry. A survey design was adopted with quantitative data gathered from construction professionals in Johannesburg, Gauteng province, South Africa. These professionals include, Architects, Construction managers, Engineers, General Contractors and Quantity surveyors in the area. The respondents were selected based on their direct involvement in the delivery of construction projects and their importance within the AEC industry. Questionnaire was adopted as the instrument for data collection. Blaxter *et al*. (2001) questionnaire is among the most widely used social research techniques. Tan (2011) further stated that the questionnaire survey is a methodical technique of gathering data based on a sample. It is easy to use and have the ability to cover a wider range of participants. The questionnaire used was designed in sections; the first section gathered information on the respondent's background. Information gotten from this section provided quality check to the answers gotten from the other section. In the second section, respondents were provided with some challenges of digital collaboration, and strategies for enhancing the use of digital technologies, and were asked to rate them base on their level of significance. A 5-point Likert scale was employed, with 5 being very high, 4 being high, 3 being average, 2 being low and 1 being very low.

A total of 60 questionnaires were distributed to these identified professionals with 52 retrieved and deemed fit for analysis. This represents an 87% response rate from the total questionnaire distributed. This 87% response rate is deemed adequate for the study as observed by Moser and Kalton (1999) which stated that a response rate of 20 to 30% is deemed adequate for survey researches. Data analyses were done using percentage and frequency for background information of the respondents, while mean item score was used to rank the identified challenges and strategies. Normality test using Shapiro-Wilk test was conducted to determine the nature of the data gathered, while Kruskal-Walis H-Test was employed in testing the significant difference in the view of the different professionals that took part in the study. The reliability of the questionnaire was also analysed using Cronbach's alpha test. Cronbach alpha gives a range of value of between 0 and 1, and the higher value, the higher degree of internal consistency. The Cronbach's alpha value of 0.795 and 0.735 was derived for the challenges and strategies

respectively. This shows that the instrument used is reliable since the degree of reliability of an instrument is more perfect as the value tends towards 1 (Moser and Kalton,1999).

4. Findings and Discussions

4.1 Background Information

Result in Table 2 shows that background information of the respondents. Result reveals that more response (44.2%) was gotten from Quantity Surveyors, while the least response was gotten from Engineers and Contractors with 11.5% each. Most of the respondents have Post-Matric Diploma or certificate (46.2%) and Baccalaureate Degree(s) (38.5%), with the least academic qualification being Grade 12 (Matric, std 10) with just 1.9%. The highest years of experience falls between the range of 2 to 5 years, and 5 to 10 years with 34.6% and 21.2% respectively. On the average, the years of experience of the respondents is calculated as 6.6 years. With this average years of experiences of the respondents coupled with their academic qualifications, it believed that they have the capacity to give reasonable response to the questions of the study.

Table 2. Background Information

Category	Classification	Frequency	Percentage
Profession of Respondents	Architect	9	17.3
	Quantity Surveyor	23	44.2
	Engineer	6	11.5
	Construction Manager	8	15.4
	Contractor	6	11.5
	Total	52	100.0
Academic Qualification	Grade 12 (Matric, std 10)	1	1.9
	Post-Matric Diploma or certificate	20	46.2
	Baccalaureate Degree(s)	24	38.5
	Post-Graduate Degree(s)	7	13.5
	Total	52	100.0
Years of experience	Less than 1 year	1	1.9
	1-2 years	9	17.3
	2-5 years	18	34.6
	5-10 years	11	21.2
	10-15 years	9	17.3
	15-20 years	4	7.7
	Total	52	100
	Average	6.6	

4.2 Challenges of Digital Collaboration

In determining the challenges of digital collaboration in the South African Construction Industry, some challenges were identified from the review of related literatures and respondent were asked to rate them based on the level of their significance. Normality test was conducted on the data gathered in order to ascertain whether the data gathered are parametric or non-parametric in nature. Since the sample size of the study is less than 2000, Shapiro-Wilk normality test was adopted as suggested by Ghasemi and Zahediasi (2012). Result in Table 3 shows that the significant value of all the assessed challenges is less than the 0.05 required criteria for normality. Hence the data gathered cannot be examined using normal parametric statistical techniques as they are non-parametric in nature. Thus, Kruskal-Walis H-Test; a non-parametric test used in ascertaining the significant difference in the perception of three or more categories of respondents, was employed in determining consistency in the opinion of the different professionals sampled as seen in Table 4.

Table 3. Normality Test for the Challenges of Digital Collaboration

Challenges	Statistic	Df	Sig.
Challenge of interoperability	0.836	51	0.000
Data security and privacy	0.873	51	0.000
Satisfaction with existing method of working	0.904	51	0.001
Expensiveness of digital technologies	0.809	51	0.000
Lack of training	0.760	51	0.000
Complexity of digital technologies	0.849	51	0.000
Increasing complexity of data structures	0.843	51	0.000
Diverse nature of systems	0.854	51	0.000
Lack of accessibility	0.861	51	0.000
Poor adoptability of standards	0.848	51	0.000

Result in Table 4 shows the challenges of implementing digital collaboration as rated by the respondents. It also shows the chi-square and significant p-value of each of the assessed challenges derived from Kruskal-Walis Test. From the table it is evident that all the assessed challenges have the tendency of affecting the implementation of digital collaboration within the industry as a mean value of well above average of 3.0 was derived. However, chief of these challenges are lack of training, expensiveness of digital technologies, poor adoptability of standards, and challenge of interoperability with a mean value of 4.29, 4.17, 3.94 and 3.94 respectively. Kruskal-Walis Test reveals that there is no statistical significant difference in the opinion of the different professionals as regards the significance of nine out of the ten assessed challenges as a significant p-value of above 0.05 was derived. However, there exist a significant difference in their view as regards the significance of expensiveness of digital technologies as a challenge to the implementation of digital collaboration. A significant p-value of 0.030 was derived for the challenge, and this below the 0.05 threshold. This implies that the respondents have a divergent view as to this challenge. This is understandable as the digital tools used by each set of professionals within the industry varies, so is the cost. While for some the cost of purchasing these technologies might not be an issue, for some, these technologies are so expensive that it requires a great fortune for the organisations to purchase them.

The issue of lack of training of construction participants in digital tools at the institution level as well as the high cost of digital technologies, have been pinpointed as a major issue affecting the implementation of the digital collaboration within the AEC industry in countries around the world. Sacks and Barak (2010) submitted that the absence of trained staffs in BIM which is a crucial part of digitalization in construction, is a noteworthy requirement preventing the utilization and appropriation of the innovation in construction. Oyediran and Odusami (2005) also reported that cost of acquiring and maintaining digital tools, and the lack of training among staffs are among the challenges of the adoption of digitalization among some construction related firms, particularly the quantity surveying firms in Nigeria. In Jordan, El-Mashaleh (2007) observed that the main obstacles of the adoption of digitalization is that of the financial cost of using digital tools and maintain them, coupled with ineffective staff training. Findings of this present study further corroborates these studies as it shows that lack of training of personnel in the use of digital tools and the expensiveness of digital technologies, can go a long way in influencing the implementation of digital collaboration negatively. It is evident that most institutes do not provide specific module on digital training and this develops a negative effect in the industry as companies have to further train their graduates themselves. This tend to lead to these organisations incurring more cost than expected.

Aside the cost of training staffs in the use of digital tools, the cost of acquiring these tools can also be too high for some companies within the AEC to acquire. Aside the training and cost issues, the adoptability of standards is evidently influencing the implementation of digital collaboration within the South African AEC industry. The lack of standards in the delivery of the industry's products inhibits the promotion of the use of digital tools. This problem has earlier been identified by Lapierie and Cotep (2008) as a major issue in the efficient use of digital technologies. Also Aranda-Mena *et al*. (2006) and Eastman *et al*. (2008) submitted that a major challenge of digital collaboration is interoperability which involves the ease of technology exchange between the different professions within the industry. As a result of the segmented nature of the construction industry, technology providers are charged with the improvement of programming and frameworks that interoperates (Doller and Hegedorn, 2008).

Table 4. Challenges of Digital Collaboration

Challenges	Mean	Rank	Chi-Sq	Sig.
Lack of training	4.29	1	5.552	0.235
Expensiveness of digital technologies	4.17	2	10.705	0.030**
Poor adoptability of standards	3.94	3	3.503	0.477
Challenge of interoperability	3.94	3	4.487	0.344
Complexity of digital technologies	3.88	5	3.344	0.502
Increasing complexity of data structures	3.79	6	2.105	0.716
Diverse nature of systems	3.75	7	1.440	0.837
Lack of accessibility	3.65	8	1.495	0.827
Data security and privacy	3.55	9	1.467	0.832
Satisfaction with existing method of working	3.40	10	1.181	0.881

** Significant at $p < 0.05$

4.3 Strategies for Enhancing the Use of Digital Tools

In determining the strategies for enhancing the use of digital tools in the South African Construction Industry, some strategies were identified from the review of related literatures and respondent were asked to rate them based on the level of their significance. Normality test shows that the significant value of all the assessed strategies is less than the 0.05 required criteria for normality as seen in Table 5. Hence Kruskal-Walis H-Test was also employed in determining consistency in the opinion of the different professionals sampled, as seen in Table 6.

Table 5. Normality Test for the Strategies for Enhancing the Use of Digital Tools

Strategies	Statistic	df	Sig.
Increased research and development	0.778	52	0.000
Ensuring easy access to loans from financial institutions to digital collaboration	0.734	52	0.000
Staff training on digital collaboration	0.743	52	0.000
Creating avenues for proper education and training on digital collaboration especially in tertiary institutions	0.728	52	0.000
Encouraging digital collaboration usage in workplaces by management	0.723	52	0.000
More Seminars on digital collaboration	0.800	52	0.000
Remove digital collaboration investment obstacles	0.863	52	0.000
Computerized frameworks usage adoption	0.802	52	0.000

Result in Table 6 shows that professionals in the AEC industry are of the opinion that all the assessed strategies have the tendency of enhancing the use of digital tools within the industry as a mean value of above average of 3.0 was derived. Chief of these strategies are creating avenues for proper education and training on digital collaboration especially at tertiary institution level, encouraging digital collaboration usage in workplaces by management, and ensuring easy access to loans from financial institutions for companies to implement digital collaboration, with a mean value of 4.46, 4.42 and 4.42 respectively. Kruskal-Walis Test conducted shows that there is no significant difference in the view of the different construction professionals as regards the significance of the identified strategies for enhancing the use of digital tools within the South African construction industry. A significant p-value of above 0.05 was derived for all the assessed strategies.

Findings of this study further affirms Staub-French and Khanzode (2007) submission on the need for trained individuals with the abilities to execute digital technology responsibility. Becerik (2004) has stated that industry associations ought to back appropriation of the advances in digital collaboration with an attention on the most proficient method to utilize and apply them beneficially in the industry. In similar manner, scholastic foundations ought to understand the duty to educate their understudies in the new advances, and creative approaches towards utilize them. Findings of this study further corroborates Mutesi (2009) findings which shows that the top three possible strategies to enhance digitalization in the construction industry in Kampala are; loans from Government and financial institution, improving and employing professionals with required skills, and staff training on job in the use of digital tools for work. The finding is also in line with that of Akinnagbe and Adelakun (2014) who observed that for enhanced digitalization, in-house training of workers is necessary, and by giving them the technical and financial support required, they can become first hand software experts. Eze *et al.* (2015) recognised the need for government to extend the hand of assistance to firms in Nigeria, particularly with a view to improving their funding and

financing capacity. This submission can to a large extent apply to financial institutions also as discovered in this study. By providing easy access to loans for AEC companies within the country, the use of digital tools among these companies can be encouraged.

Table 5: Strategies for Enhancing the Use of Digital Tools

	Mean	Rank	Chi-Sq.	Sig.
Creating avenues for proper education and training on digital collaboration especially in tertiary institutions	4.46	1	2.859	0.582
Encouraging digital collaboration usage in workplaces by management	4.42	2	3.818	0.431
Ensuring easy access to loans from financial institutions for companies to implement digital collaboration	4.42	2	5.378	0.251
Staff training on digital collaboration	4.29	4	6.422	0.170
Increased research and development	4.29	4	5.667	0.225
Computerized frameworks usage adoption	4.15	6	1.750	0.782
More Seminars on digital collaboration	4.06	7	5.012	0.286
Remove digital collaboration investment obstacles	3.77	8	0.398	0.983

5. Conclusion

This study set out to investigate the challenges of digital collaboration and the possible strategies for enhancing the use of digital technologies in the South African construction industry. Using a survey approach through the administering of questionnaires on construction professionals in Johannesburg, Gauteng province, South Africa, the study has been able to ascertain the key challenges of digital collaboration and the possible strategies for enhancing the use of digital technologies within the country. Based on the findings, the study concludes that the major challenges of digital collaboration in the South African construction industry are lack of training, expensiveness of digital technologies, poor adoptability of standards, and challenge of interoperability of digital technologies. However, in order to mitigate these problems and improve the use of digital tools within the industry, strategies such as creating avenues for proper education and training on digital collaboration especially at tertiary institution level, encouraging digital collaboration usage in workplaces by management, and ensuring easy access to loans from financial institutions for companies to implement digital collaboration, are necessary. The study therefore recommends that aside individual training of staffs by companies, the study of digital technologies should be included and taught as a module in tertiary institutions, with a view to producing digital technologically inclined graduates. By so doing, cost of training of these graduates incurred by their respective companies can be reduced. Also construction participants, especially those in top management positions can be further enlightened through seminars and workshops organised by their respective professional bodies as regards the need for, and benefit of the implementation of digital collaboration in their organizations. Since digital technologies are expensive Government can to a large extent help in solving this problem by extending the hand of assistance to AEC companies in the country, particularly with a view to improving their funding and financing capacity.

It is believed that the findings of this study will assist AEC companies within the country in understand the major obstacles which may hinder them from achieving tremendous success in the delivery of the services as a result of non-implementation of digital collaboration in their organizations activities. It also brings to light the areas that need to be improved upon if successful construction projects are to be delivered through digital technologies. However, the major limitation of the study lies in the fact that the study was carried out in Gauteng province of South Africa. Further studies can therefore be carried out in other areas of the country in order to compare results. Also further studies can be carried out in assessing the effect of digital collaboration on construction project delivery within the South African construction industry.

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